The Sound Labyrinth

The Sound Labyrinth: Computers, Constructionism and Language Learning

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ABSTRACT
This contribution presents The Sound Labyrinth, which is an application software that was designed to support the learning and safeguard of Silbo Gomero, a whistled from of language. Once used by the islanders of La Gomera, this unique form of communication has been revived, shifting from the fields where it was once used by agricultural laborers and into the space of the classroom. Here, it has integrated the school curriculum, providing children with a unique opportunity to engage with local intangible heritage. As a response to this transformation, the island's educational community has identified a new challenge: the need to develop didactic materials that resonate with the generational interests of local children. Drawing on the work Papert, Bamberger, amongst others, this contribution presents and discusses the application software that was designed in response to this challenge. Pushing the boundaries of constructionism, this contribution equally demonstrates how software might contribute to the domain of linguistic heritage.

Author Keywords
whistled language; endangered languages; intangible cultural heritage; virtual acoustics; interface design; learning environments

ACM Classification Keywords
K.3 [Computers and Education]: General.

INTRODUCTION
The Silbo Gomero is a whistled language that was once used by the islanders of La Gomera (Canarian Archipelago, Spain). After fifty years of almost total extinction, this form of communication was revived, shifting from the fields where it was once used by agricultural labourers and into the space of the classroom. Against this backdrop, this contribution will present The Sound Labyrinth, an application software that was developed in response to Silbo Gomero's integration within the school curriculum. Supported with the evidence that has resulted from a study of whistled language and its historical and cultural context, the ultimate-goal of this contribution is to consider whether interactive technologies could play an important role in the learning and safeguard of endangered forms of language.

Using an ethnographic approach to research [1] that included direct observation, interviews, informal conversations and participation in class, the fieldwork that was carried out on the Island of La Gomera would soon demonstrate that Silbo Gomero had integrated the curriculum of the island's schools, providing children with a weekly class that was led by one of two teachers that still taught whistled language. Documented elsewhere [2] [3], the two teachers were not formally trained as such and rather learned *Silbo*[1] at a young age and while working in the fields of the island with family members.

Visiting the island on a yearly basis - for two to three weeks at a time - and over the duration of a two-year period, it was soon apparent from the sessions of direct observation and participation in class and through a series of informal conversations with both teachers and with other members of the island's educational community, that a transformation was taking place. The *Silbo* was shifting from the field and into the space of the classroom and this change would carry profound shifts. Firstly, an integration within the school curriculum and within a classroom environment would mean that whistled language was now taught in an enclosed space, very different to the steep terrain where Silbo Gomero was once used. Secondly, whistled language was now taught to children who were also formally learning other languages, such as Spanish and English. It is important to note that prior to the institutionalization of *Silbo* and its recognition as protected intangible heritage by UNESCO [4], whistled language was mostly used by agricultural labourers who rarely had the opportunity to attend school and to learn how to read and write. Finally, the Gomeran educational community recognised that

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1 Silbo Gomero is often locally known as *Silbo,* meaning 'whistle' in Spanish.

children were now exposed to a very different set of media. This would mean that future ways of teaching *Silbo* would have to respond to the children's culture and environment, one that was becoming equally influenced by the presence of desktops, laptops and mobile computers at school and at home.

As a response to this transformation, and the need to develop learning materials, the project that is here reported would proceeded by taking into account the phonological [5][6][7], bioacoustic [8] and cognitive [9] studies of whistled languages and of Silbo Gomero more specifically. However, it was the ethos of constructionism as well as the situated research developed while living on the island of La Gomera that would instigate a new approach to the design of learning materials for Silbo Gomero. In fact, it was the view that learning should not be understood as a process of transmission but rather as a constructive process [10] that would guide subsequent readings as well as their application in the design of the application software that will be presented and discussed in the following sections.

SILBO GOMERO: AN INTERDISCIPLINARY APPROACH

Whistled languages have been found in almost all continents [8]. However, what makes Silbo Gomero unique is its survival. Recognised by UNESCO as world intangible heritage [4], today, Silbo Gomero integrates the curriculum of all public schools of the Island of La Gomera. The most detailed accounts of *Silbo* appear in the work of linguists Ramon Trujillo [5] [6] and Annie Rialland [7], in the work of psycholinguist Manuel Carreiras and colleagues [9] and in the work of bio-acoustician Julien Meyer [8]. In all four accounts, *Silbo* is portrayed as an independent phonological system that is used to communicate (through a set of whistles) the Castilian Spanish that is spoken on the island. Used by local islanders to communicate across the steep and mountainous terrain of La Gomera, *Silbo* presents two whistled vowels and four consonants that vary in duration, pitch and frequency [5][6][7][8]. Resembling the "generative primitives" of musical competence that are described by Jeanne Bamberger [11], whistled vowels and consonants are the basic units upon which more complex words and sentences can be built from.

What is important to retain from a very brief presentation of whistled language, is that despite the proximity to the local spoken language (in this case, Spanish), *Silbo* should not be understood as a surrogate of speech [6][7]. A point of debate amongst some scholars [6][7], presenting the *Silbo* as an independent phonological system, with its own characteristics, has led to an understanding that those who use *Silbo* possess unique cognitive traits [8][9]. In fact, in the bioacoustics studies of Meyer [8], it was found that whistled languages are only the 'tip of the iceberg' of more complex cognitive phenomenon. For this same reason, the process of learning whistled language is often compared to the process of learning a musical instrument [8].

The phonological, psycholinguist and bioacoustics studies of whistled language can be further complemented with the interdisciplinary study of sound that was produced by Augoyard and Torgue [12] and that offers an understanding of how diverse physical environments shape our relationship to sound. Attuned to the fieldwork that was conducted on the island of La Gomera, the authors suggest that the surrounding environment can be understood as an instrument – or '*instrumentarium'* – "a reservoir of sound possibilities, (…) [that is used] to give substance and shape to human relations and the everyday management of (…) space" [12]. This was easy to observe when documenting whistlers outside, working in the fields. In fact, the abrupt terrain of the island would often offer a dramatic set of echoes and reverberations that were exploited by whistlers to aid their projection of a whistled utterance. Conversely, intense reverberations and echoes could also appear as obstacles to those who were placed in the receiving end of a whistled message. As observed during fieldwork, these different 'interferences' would play an important role in the cognitive development of whistlers, subtlety transforming their auditory skills - a key aspect that was also documented by Meyer [8].

THE SOUND LABYRINTH

The Design Concept

During the fieldwork that was conducted as part of this project, it became apparent that the two local teachers that were responsible for a weekly class of *Silbo* had devised their own unique teaching methods. One teacher, would use a self-devised alphabet known as the *Silfateo.* This alphabet was used when encouraging children to playfully combine whistled vowels and consonants and when constructing the syllables of whistled words. Furthermore, the other teacher would favour a method of learning-by-hearing, one that resembles the process of learning a musical instrument through improvisation. In both instances, there was a clear preference for experimentation over rote learning or the transmission of facts.

Figure 1: Child whistling in class.

Briefly described in the previous section, the bioacoustic and cognitive studies that tackle whistled languages greatly influenced the development of a design concept for the project. Both Meyer and Carreiras and colleagues suggest that those who learn whistled languages develop unique cognitive traits [9], which are comparable to the cognitive traits of musicians [8]. When designing The Sound Labyrinth this point offered a new ground for experimentation. Combined with the methods that were devised by the two teachers, and with some of the lessons that have been conveyed by constructionism [13], it soon became clear that the aim was to design an interactive platform that would invite children to experiment with the sonic qualities of whistled language.

Documented in two additional publications that have resulted from this project [2][3], The Sound Labyrinth is an application software that was designed as a language support system, an 'object-to-think-with' [14]. To be used within the context of Gomeran schools and to support local children when learning Silbo Gomero, it is important to note that when the application software was developed most Gomeran schools had a computer lab with desktops and where children could access a range of software, each one directed toward a specific topic or discipline. However, to date, nothing was developed to suit the children's exploration of whistled language. Paired with the didactic approaches that had been devised in class by the two local teachers, the intention was to design a platform that would suit the existing ICT infrastructure available on the island as well as the approach to language learning that the two teachers were using for the past twenty years. On this view, the role of The Sound Labyrinth was to stretch their influence even further as opposed to replacing their role as teachers. Also, and in line with Papert's critique of applications that simply mimic real world phenomena [15], the The Sound Labyrinth was not designed to mimic the outdoor environment where *Silbo* was once used. The goal was to rather offer an '*instrumentarium*' [12] that would aid local children in their learning of *Silbo*.

Constructionism became a decisive reference when rethinking the role of didactic materials for whistled language. After documenting the community's concern for developing learning materials that would accompany the children's own generational interests, as well the teachers unique teaching techniques, it was soon clear that Papert's 'computer as a medium of expression' [15] would be the right paradigm when devising a platform that would allow children to explore Silbo Gomero in a constructive and exploratory way. Therefore, The Sound Labyrinth was created in the attempt of offering local children an opportunity to construct their own stories while using whistled language.

The Software Environment

Figures 2 and 3 demonstrate the platform through a documentation of its visual interface. Designed with only a set of reduced visual cues, the interface of The Sound Labyrinth was designed to invite children to explore sound as the primary means of communication and interaction. Therefore, one key aspect is the possibility of spatially organising and distributing a range of sound sources. To do this, children can use the application software to add whistled words, sentences and dialogues that are recorded there and then and while inserting a yellow sound source. Children can also add sound sources that have been previously saved as a sound file on the computational medium – here represented by the orange and blue circles.

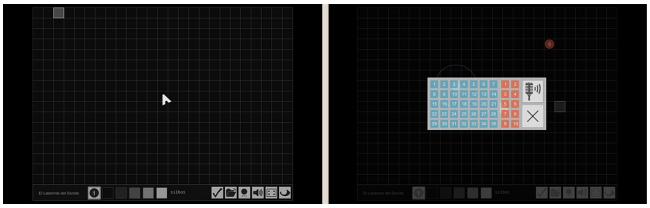

Figure 2: Snapshot #1 & 2 of The Sound Labyrinth.

Looking at the right-hand side of the menu bar, the reader will notice an icon in the form of an 'eye'. By clicking on this icon, the sound sources will disappear and the child will be presented with a dark screen, a feature that was added to provide a mode of interaction that is purely aural and that should be used once a story has been created. Here, it is important to mention that a binaural algorithm was used to create a binaural sound field that emulates the way in which humans spatially hear the surrounding world [16]. As mentioned above, the interface itself will afford children the possibility to distribute sounds spatially. When both combined, the experience provides children an immersive environment where they can create stories as well as hear stories that were created by their classmates and teachers.

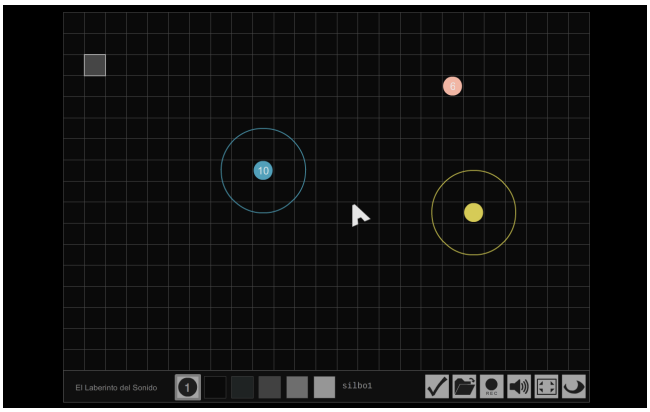

Figure 3: Snapshot #3 of The Sound Labyrinth.

Figure 3 demonstrates some of the sound sources with a surrounding circle while others (such as the oranges circles) are devoid of this feature. This will mean that some sound sources (such as the orange one) can be heard throughout the environment, even though their intensity will vary depending on the cursor's proximity to the sound source. On the other hand, the sound sources that are presented

with a surrounding circle can only be heard once the cursor is within the boundaries of the surrounding circle. It is important to note that this circle can be removed. Finally, a set of grey squares can be 'painted' directly onto the interface, this will add more-or-less reverberation to the surrounding sound source and depending on the shade of grey that is chosen by the user.

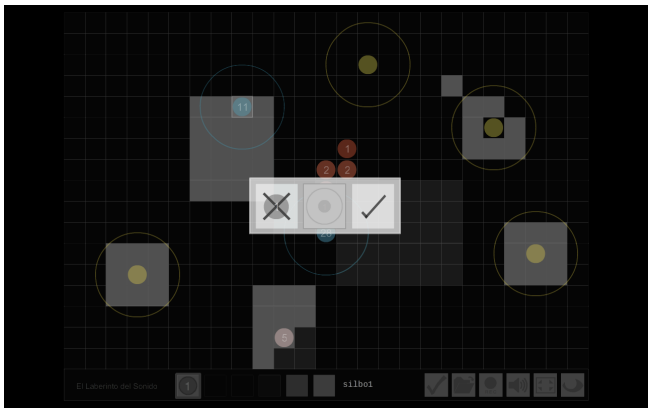

Figure 4: Snapshot #4 of The Sound Labyrinth.

TESTING THE APPLICATION SOFTWARE

The setting

The Sound Labyrinth was first tested at CEIP El Retamal, a school situated in the municipality of Valle Gran Rey on the western part of the island of La Gomera. The school follows Spanish educational guidelines this considering that the Island of Gomera integrates the Canarian archipelago, an autonomous region of Spain. According to the information that was provided by the local Educational Bureau, in line with most EU Member States, Spain has also shown an interest in the modernization of the school system, particularly through the implementation of computers in the classroom. In the Canary Islands, particularly on the island of La Gomera, the development of an educational digital culture was implemented through *Proyecto Medusa* (Medusa Project) [17]. This project brought to CEIP El Retamal twelve desktop computers that were set in one of the schoolrooms and where the children would engage with information and communication technologies (ICT's), once a week and for the period of one hour.

According to one of the teachers that was interviewed, not all teachers had incorporated *Proyecto Medusa* within their own teaching. In fact, some were suspicious of forcing computers into the classroom, this considering that "what might work for a specific subject area might not necessarily work for all". In fact, this seemed to be a common approach amongst teachers at CEIP. "It all depends on how one incorporates these tools, the same could be said for a pen and pencil", was how one teacher addressed the topic during an interview. This episode resonates with Papert's concerns that highlighted how computers were at times blindly introduced to educational settings without however taking into account a school's underlying culture [15]. Considering this, one could conclude that, despite having a basic computerized infrastructure, CEIP El Retamal was not incorporating computer-based learning to foster everyday learning activities. This was partially influenced by the teachers' own idiosyncrasies and, overall, by their limited technical understanding of computers, as well as the instructional nature of the curriculum that was in place.

However, and contrary to the observations that are documented above, the children who participated in the evaluation of the application software showed great fluency with computers, a fact that might have been aided by *Proyecto Medusa*. To strengthen this idea, the teachers that were interviewed confirmed that most children had computers at home and would therefore learn how to use the computer almost intuitively, often being in a better position to teach adults how to use one. This generational gap was also documented in the constructionist literature and in relation to the introduction of the LOGO programming environment [10] . However, some of the children that participated in this initial user-testing session only had the possibility of accessing a computer at school and in the computer-room that was provided by *Proyecto Medusa*.

Testing the Application Software: Ages Eight and Nine

Two groups of children with ages eight and nine were chosen to test the application software. This choice was influenced by two factors: (1) fluency with Silbo Gomero (children start learning whistled language at age six and upon entering elementary school) and (2) the children's ability to understand the nature of the proposed activity - the creation of stories using whistled language as well as other sources of sound. When testing The Sound Labyrinth activities were divided amongst six sessions of one hour each and in the afternoons after class and when children would normally have time to use one of the rooms that was reserved for the project. Hence, it is important to note that we did not use the computer-room that was provided by *Proyeto Medusa,* this considering that the beta version of the application software was designed for a Macintosh system that was not available in the school.

Group 1 was composed by four children while group 2 was composed by five children. The initial session was followed by a thorough presentation of the designed application. Also, in this first session, and for the first thirty minutes, I adopted the role of transmitter however quickly becoming a facilitator when the children showed interest in trying out the application software and clarifying their own doubts. In both groups the children demonstrated a special interest during the facilitating stage where they could closely engage with the application software. The transmission phase was purely informational. For this same reason, the children did not engage with such eloquence. In fact, confirming the value of a constructionist approach where children are in charge of their own learning process [10]. For this same reason, in subsequent sessions it become clear

that it would be better to initiate the session by inviting children to explore the application software in groups and without my direct intervention.

The second session was dedicated to the development of a story while exploring previously discussed concepts such as the auditory, temporal and spatial qualities of Silbo Gomero. An exploration of the non-linear 'editing' space of the application software and how it could be used to influence the story was also discussed. The first group, was very quick in exploiting to its maximum potential the flexibility of a non-linear approach. This group's story was based on the idea of a labyrinth where the listener approaches distinct doors that lead to distinct parts of the story. For each part of the story, the group recorded a set of sentences that the children performed in whistled language as well as a set of sounds that were provided upon request. The second group, decided to create a set of shorter stories that were unrelated. For this same reason, they did not exploit the non-linear nature of the application software to its fullest potential, at least when compared to the first group.

Figure 5: Children designing an interactive story.

It would be important to highlight that the second session provided an opportunity for children to construct a story as a group while splitting the tasks amongst each member. Some, who were more proficient in whistled language, gave suggestions for possible utterances while others, more prone to narrative exploration and construction, provided structural cues. To complement this session, each group was given a squared sheet of paper, resembling the interface that was designed for the application software. The children used this sheet to take note of each sound source and to carefully decide where each one would be placed within their project. This proved to be useful, this considering that we only had one computer per group. Also, with this sheet of paper the children could more easily circulate ideas amongst each other. However, and perhaps more importantly, the additional sheet acquired a life of its own this considering that the children would use it to "think with" [14][11]. Paraphrasing the words of Bamberger, this sheet became a 'symbolic notation' [11] that was used to make sense of the spatial organization of their story.

The third session was devoted to recording whistled utterances directly and while using the application software. Groups were divided between those who wanted to perform whistled utterances and those who showed more interest in working directly with the computer. In the third session, one group appeared to be more dynamic, manipulating the computer as well as participating in the performance of whistled utterances. In the other group, some challenges were faced, this considering that one of the group members initially disliked working with the computer. What was interesting to observe was that after a couple of sessions this child gained a real interest in the application software and slowly felt more at ease with the computer as a tool.

The third session was aimed at developing collaboration and teamwork. Students had to record whistled messages and periods of silence had to be agreed and respected. Also, when the group was not happy with a specific whistled utterance they would have to motivate each other to repeat the process. The dialogue that is presented below provides an example:

Child 1: "*Parad*. Did you understand?"

Child 2: "No! It does not sound like *parad*!"

Child 3: "*Parad* is more like this….[child 3 whistles]."

Child 2: "So let's change it." [Child 3 gives a final try but finally child 1 repeats the whistle successfully].

Child 2: O.k. "Now we got it!"

Figure 6: Children recording their story.

Harking back to the work of Bamberger, the children's discussion of the word *parad* (to stop, in Spanish) demonstrates that they were actively making sense of the sounds that were being heard and performed in real-time. This 'active process of sense-making', as Bamberger would suggest, draws on a negotiation of the 'similarities and differences' of what can only be heard individually [11].

During the final two sessions, each group was asked to complete the narrative while inserting new sounds as well as exploring the reverberation that could be 'painted' directly onto a sound source. The additional sounds were provided directly to the children and were recorded on the island and based on suggestions that were made by the children. It is important to consider that the final activities were done with greater ease this considering that the children were now comfortable with the application software. Also, it is important to note that during the initial two sessions, the children avoided using the stronger reverb this considering that the higher the reverb, the greater the distortion of whistled utterances. Only with time did the children become interested in experimenting with this feature.

During the last session, the two groups were brought together in a joint activity and where both stories were on display. The setup was comprised of two laptop computers with two headphones each. The goal of this session was to hear the story that was created by the other group and to decipher all whistled utterances. Here, the screen was faded and the children could only use a drawing pad to explore the interface while uncovering the story and each utterance. Overall the task was not always easy and often the children had difficulty when deciphering the story. This enhanced their curiosity to explore each sound source more than once. Just as the discussion of the word *parad*, the act of deciphering each utterance was an exploratory process where each child was invited to make sense of the different whistled utterances that were hidden in each story.

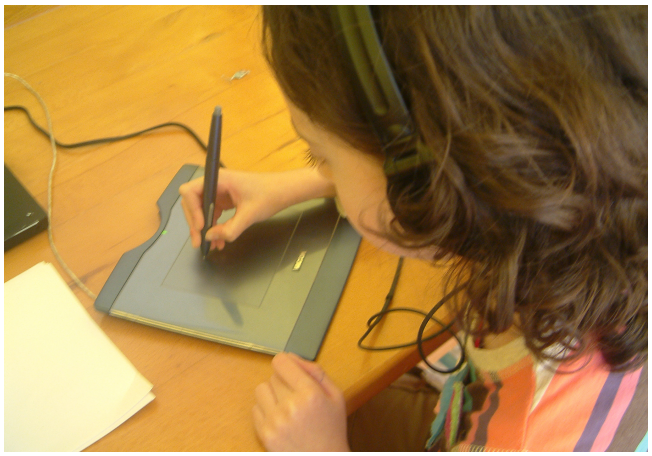

Figure 6: Child interacting with the story of another group.

The relative difficulty that the children experienced when deciphering the story and the different whistled utterances also instigated fruitful discussions amongst the children. Once again, what was particularly interesting to observe was the debate as to whether the word *parad* was being whistled correctly. Already presented in the previous dialogue, once again this word would instigate a debate amongst the children and as seen below:

Child 4: "there it seems like *aiai"*

Child 5: "*Parad*…this one?"

In fact, in the final session, the word *parad* would draw both groups together in a lively discussion that was aided by a set of demonstrations of how the word should be whistled. When later presenting a video recording of this discussion to one of the teachers of Silbo Gomero he responded by stating the following:

"They still do not know how to vocalize but they are searching for the sounds, the sound that the word carries. Not the expression but the sound."

The children's discussion and the teacher's remarks, illustrate the ethos of constructivist learning. Here, the focus is not on what is being learned but rather how, in which social and cultural context [18] and through which means will learning occur. In the end, the *Silbo* teacher rightly observes that it is the process that leads to learning. In the case of Silbo Gomero, the process of searching for the sounds, the building blocks of whistled language (here attuning to Bamberger's 'generative primitives'), is key.

The children's feedback

Later, at the end of the session, when all activities were complete, two of the children went back to the application software to decipher some of the utterances that were still missing. Considering that we only had two headphones per laptop, during the last session a small video camera was provided to those who were waiting for their turn to interact with the story. Upon my suggestion, and with the camera at hand, some of the children documented their experience of the project. The video footage that was collected by the children became a key asset for the project. In fact, while producing their own 'documentary' the children had the opportunity to reflect on the usability, comprehension and utility of the application software. From this footage, it would be important to outline the following comments:

Child 6: "We learned how to use it to build a narrative."

Child 3: "Yes, because it is very interesting and we learn more things" [referring to the application]. "One of the sentences is *buenos dias.* You say it like this…." [child 3 whistles]. "I also learned how to whistle a sentence I did not know before."

Child 2: "It was bit difficult…. let's say a bit" [referring to the application software].

In these three moments one can sense ways in which the The Sound Labyrinth enhanced a language learning process by introducing a novel and constructive approach. The application software also enhanced the learning process that was already initiated during the weekly class of *Silbo*. This is particularly visible in one comment: "I also learned how to whistle a sentence I did not know before". This comment also sustains an understanding of the application software as a system that supports exploration of unknown vocabulary. In this respect, and if we take into consideration that The Sound Labyrinth also encouraged

children to look for the basic sounds, the building blocks of whistled language, one can also conclude that the platform posed manageable challenges to the children. In fact, echoing the early work of Lev Vygotsky [18] who suggested that learning was best promoted while establishing 'zones of proximal development'; briefly, this concept sustains the idea that activities and learning materials should aid and guide children in the exploration of unknown domains.

Testing the Application Software: Age Seven

Another phase of experimentation with The Sound Labyrinth was conducted amongst the children that were attending the second-grade class at CEIP El Retamal. With seven years of age, this session would benefit from the involvement of a lead teacher that was keen to experiment with the application software as a transversal activity that would cut through diverse levels of the language module, one that integrates Castilian Spanish and whistled language. To achieve this, the lead teacher suggested using a storytelling project that she had initiated in class. The story consisted of distinct dialogues that were developed by all fifteen students that were attending the second-grade class. Whistled utterances were inserted in some parts of the story while other parts were delivered in spoken Spanish. With this material, which was recorded in class with the children, the lead teacher would use the application software to design an interactive story for the class to interact with.

In this user-testing session the aim was to provide second-graders with a rich auditory experience. In response, an interactive 'collage' of distinct sounds was orchestrated by the lead teacher. Whistled and spoken utterances that were recorded in class would now compose a non-linear and interactive story for the second graders to explore. Hidden in the sound collage were a set of whistled utterances, the names of characters *Arturo*, *Manolo* and *Carpa*. More difficult sentences were also provided such as *fuera bichos* ('go away creatures'). Surrounding each one of these utterances was a collection of sounds that framed the story such as sounds of the ocean, water, frogs and birds that were once again recorded on the island.

To test the story that was created by the lead teacher a setup with one laptop and two simultaneously connected headphones was provided. Various groups of children interacted with the story. To illustrate their interaction with The Sound Labyrinth, the dialogue that is provided below can be used to support the analysis of the application software.

Child 7: "What was that?"

Child 7: "Continue moving."

Child 7: "Maybe through there."

Child 8: "Now that was a really big wave."

Child 7: "Another *silbo*."

Child 8: "I am almost sure what they are saying: *ven pa'ca"* (come here).

Child 7: "Did you listen to that?"

Child 7: "Hear the words."

Child 8: "Yes, it's [the word] *Carpa* because it's shorter."

Child 7: "Now think…." [here the children were trying to remember what was recorded in class].

[The two children fully concentrate on a specific whistled utterance].

Child 7: "*Fuera bichos"* (go away creatures).

Child 8: "Yes, super!2 [the two children finally deciphered all four utterances].

Figure 7: Children age seven interacting with the application.

The rich interaction between the two children that is illustrated above demonstrates, once again, the potential of the application software to support children in their search for the 'right sounds'. However, some difficulties were found amongst the different pairs of children that interacted with The Sound Labyrinth in this session. Often some level of difficulty was identified, particularly when the children could not find any sounds unless they moved the pen to the outer edges of the tablet. This constraint was influenced by teacher's own design that only placed sounds in these same locations. Despite this, the interaction between the different pairs of children and the application software demonstrated potential, particularly in terms of language comprehension.

Just as in the previous section where the word *parad* was thoroughly analysed, the interaction between two other children also provided pertinent information and as indicated below:

Child 9: "Do you find a *silbo* there?"

Child 10: "Can you hear it? I think I found one around here…."

Child 9: "Very good! Carpa."

Child 10: “It's difficult, isn't it?” [referring to the hidden and ‘masked’ utterances].

While the children’s discussion can be approximated to the earlier discussion of the word *para*’, here it is important to emphasize that this group of seven-year olds did not engage in such a rich dialogue, particularly when discussing the meaning of each whistled utterance. This could be related to one of the children who was more proficient in Silbo Gomero. As there were only two children to exchange ideas concerning whistled utterances, this disparity seemed to create an imbalance. Amongst the third and fourth grade students that were presented earlier on, the dynamics was very different. This might be related to the number of participants in each activity as the number was considerably higher. It could be suggested that a slightly larger group will keep in balance the number of proficient and less proficient whistlers, the number of children who were better in perceiving the complex whistled utterances and the number of children who demonstrated more-or-less proficiency when interacting with the application software. However, this is something that would need to be repeatedly tested with larger and smaller groups and across varying age groups and as a way of drawing a more robust conclusion.

Feedback from the community

Feedback from the community was received during two presentations of the project. One presentation was delivered to one of the two teachers of Silbo Gomero and to the lead teacher that was working with the second graders. The other presentation was delivered to a representative of the Canarian Educational Bureau. The feedback provided by one of the two *Silbo* teachers can be seen in the dialogue below:

“This is an incredible sensitivity (referring to the emphasis that was made on the *Silbo*'s auditory body of knowledge and its relation to the surrounding natural environment of the island). How much this could support the children. This should be in all the schools. A tool that supports them so that they can progress within this field”.

Feedback from the lead teacher that worked with the group of second graders emphasized the importance of the application software to help the children contextualize what they are learning. On the other hand, a representative of the Canarian Educational Bureau suggested that “they [the children] are working not only the *Silbo*, the stories, comprehension, communicational competence that is now so much valued”. As she would contend: “[this] has an application. We are now introducing new technologies as part of new educational laws. It is important to work communicational competences. Even more the *Silbo* as a Canarian context”. She would finalize her feedback by stating that: “It seemed to me that the children like to learn in this context”.

All three presentations and the feedback that was collated in response to a presentation of The Sound Labyrinth had a positive outcome. As a consequence, a final version of the application software is available on the *Proyecto Medusa* web portal [19].

DISCUSSION

Despite the presence of *Proyeto Medusa,* one could not find a computer culture within the context of CEIP El Retamal. Informal conversations with the school’s teachers pointed towards a similar scenario in other public schools of the island. In CEIP Retamal, computers were mostly used outside the classroom and confined to a few hours a week. Also, the computer room was only used to explore specific subject areas, excluding Silbo Gomero. Finally, the software that was available was more instructional in nature. Following Papert’s own thoughts [15] one could state that the school lacked the institutional culture that would allow teachers and students to use computers to radically transform the way in which children learn. However, the evidence collected in this study suggests that Silbo Gomero as well as an application software such as The Sound Labyrinth have the potential to introduce constructionist modes of learning within the island’s schools. In fact, one of the contributions provided by the application software can be seen in the shift from an instructional mode of learning toward a constructionist [10] one and where children are in charge of their own process of learning. On that note, The Sound Labyrinth was designed as a tool as well as an ‘object-to-think-with’ [14]. Used to record, create as well as listen to stories that use whistled language, the children’s interaction with the application software demonstrated the potential to aid them in the exploration of the form and meaning of the basic units of Silbo Gomero.

The recurrent discussion regarding how one should whistle the word *parad* was particularly insightful. Reconnecting to Papert’s own thoughts, namely to his concept of ‘debugging’ [10], it was clear that the application software could provide children an opportunity to experiment and learn with their own mistakes. Even though faults were encouraged within the weekly class of *Silbo*, the episodes that are here described demonstrate how the computer could be used to promote what the constructionist literature would qualify as: “children’s growing tolerance for their own "errors"”[10].

Moreover, the application software also enhanced a mode of learning that was already taking place during the weekly class of *Silbo*. In this sense, The Sound Labyrinth materialized what Turkle and Papert [20] would identify as an ‘epistemological pluralism’ that seeks to “accept and validate multiple ways of knowing and thinking”. In this case, a mode of knowing and thinking that is attuned to Silbo Gomero’s original use by the local islanders that mostly did not have access to modes of formal education

and that would learn *Silbo* while working the mountainous terrain of the island.

Later on, the two pilot tests demonstrated how the application software promotes a 'mode of learning by making' while positioning the child as a designer in his or her own right, a dimension that has been explored in the constructionist literature for quite some time [13]. Revisiting once more the work of Bamberger [11], the two user-tests equally demonstrate that the application software can support the development of a hearing culture that is highly performative. In the author's own words: "developing a "hearing" of a composition as it unfolds in time is a *performance* and performances (both silent and out-loud) involve a process of active sense-making occurring in real-time". This 'active process of sense-making' is particularly noticeable in the children's discussion of the word *parad*. Just as the group of children that were documented by Bamberger, the children reported in this contribution would often make sense of what was being whistled by simply negotiating the 'similarities and differences' of what was heard individually. And while we must be careful with simplistic comparisons between whistled language and musical learning and competence, this negotiating process could be said to aid the 'classification, naming and identification' [11] of the sound objects that are key to Silbo Gomero.

The Sound Labyrinth, the two pilot tests as well as the feedback that was received from key stakeholders demonstrate that the application software was well received by children learning Silbo Gomero, by teachers and by the broader educational community of the island of La Gomera. Further improvements could be made, particularly by addressing the teaching community and how the application software could be used by teachers to create stories in whistled language and that can be later explored by children.

More importantly, The Sound Labyrinth raised pertinent questions regarding constructionism, learning and language heritage. Initially, the application software was designed with the goal of offering the educational community of La Gomera a platform that could contribute toward the curricular safeguard of whistled language. However, the most telling aspect is that the application software offered the community an opportunity to introduce a constructionist agenda within the island's schools. Although endangered languages are often understood as 'a thing of the past', The Sound Labyrinth demonstrates that perhaps linguistic heritage can point towards new ways of learning. In fact, confirming the words of anthropologist Wade Davis [21] who suggested that the variety of human languages offer a range of different "ways of thinking and interacting with the world". The application software that is here described as well as its use by the children of La Gomera demonstrate that endangered forms of language can instigate new modes of learning. And while an older generation of whistlers might see the *Silbo* as a way of transmitting a culture of the past, the process of learning whistled language while using The Sound Labyrinth might point towards the development of a hearing culture for the future.

CONCLUSION

Constructionism has influenced the development of several studies and design applications. The SIGCHI community alone has acknowledged the timely influence of constructionism on our understanding of children's interaction with computers, namely when learning mathematics and programming [22][23]. Perhaps, less explored, is the constructionist influence on the design of 'objects' that can be used to facilitate language learning and expression. It was exactly this premise that this contribution has proposed to exemplify. Through a presentation and discussion of The Sound Labyrinth, this paper proposed ways in which constructionism and language learning can be used to make small incremental shifts within instructional based teaching environments and where linguistic heritage is at stake.

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